

1 I CLAIM:

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3 1. Method for characterizing a ballistic item including the steps:

- 4 a. Produce a sequence of digitized infrared images of the item at different focus points such that
5 the deepest to the highest features are each in sharp focus in at least one image,
6 b. tag each image with the ID of the item,
7 c. tag each image with specifics of the imaging set-up including the focus position, and size of
8 digitized image array
9 d. store the tagged image sequence in a database

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11 2. Method of claim 1 with the additional step:

- 12 e. produce a photomontage from the tagged image sequence in which each section of the montage
13 image is the corresponding section of the image from the tagged sequence in which that section is in
14 sharpest focus

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16 3. Method of claim 1 or 2 with the additional step:

- 17 f. replace each tagged image in the sequence with a tagged extracted feature image containing
18 only features at least a specified size extracted from the tagged image

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20 4. Method of claims 1, 2, or 3 with the additional steps:

- 21 g. add to each tag weapon-specific ancillary information including calibre, type of ammunition,
22 direction of twist, number of lands, serial number
23 h. add to each tag incident-specific information including type of crime committed, location where
24 item was found, associated names, method of crime

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26 5. Method for identification of a ballistic item including the steps:

- 27 a. characterize the unknown ballistic item by producing a tagged image sequence
28 b. compare the image sequence with those contained in a database
29 c. determine those sequences in which one or more images are similar to the unknown tagged
30 image sequence

1 f. Display the similarities and dissimilarities in the tagging information along with the extracted
2 features for further consideration by a ballistics examiner who reviews the display and rules that the
3 unknown ballistic item is a match to an item in the database if the tagging information as well as the similar
4 pair(s) of extracted features are sufficiently alike.

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6 12. Method of Claim 11 in which step f. is performed automatically by further image processing.

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8 13. Method of Claim 1 including also the steps:

9 e. heating or cooling the ballistic item to vary its temperature

10 f. producing an image sequence in which both focus and temperature are varied

11 g. tagging each image with the corresponding temperature.

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13 14. Method to identify illumination-induced artifacts in visible light photography of ballistic items including
14 the steps:

15 a. Produce visible and IR image sequences of the same ballistic item

16 b. extract features from each image in each sequence

17 c. tag as a candidate illumination-induced artifact each feature in a visible image which does not
18 have a corresponding IR feature

19 d. tag dark visible artifacts as possible shadows and light artifacts as possible glint

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21 ~~15~~ ² Method of claim ¹ ~~14~~ in which spectral filters are used to tag certain artifacts as possible debris including
22 oil, gunpowder, fingerprints.

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24 ~~16~~ ³ Method for distinguishing lands and grooves in visible light photography of ballistic items including the
25 steps:

26 a. produce visible and IR image sequence of the same ballistic item

27 b. extract features from each image in each sequence

28 c. readjust the look-up table of gray scale allocation for the visible image such that the resulting
29 image most closely matches that of the IR image

d. Display the resulting visible image which will have more consistent appearance of lands vs. grooves.

17. Method to differentiate manufacturing marks and weapons-related tool marks on shell casings

including the steps:

- a. adjust the focus on the IR camera such that the manufacturing marks are in focus
- b. adjust the temperature of the ballistic item such that the manufacturing marks are most distinct from the surrounding area
- b. threshold the resulting image to create a template of the manufacturing marks to be used for matching or for eliminating the marks from that image prior to further matching

18. Method to detect residue on a ballistic item, including the steps:

- a. apply a sequence of spectral filters to the IR camera
- b. for each filter, vary the focus to produce an image sequence
- c. extract features from each image in the sequence
- d. compare the feature sets in images which have the same focus setting but different spectral filters
- e. display those features which are filter-sensitive as possible residue
- f. Annotate features with likely type of residue based upon the filter sensitivity.

19. Apparatus for characterizing a ballistic item including:

- a. IR camera with lenses and focus control
- b. Mechanism for varying the focus control to produce a sequence of images
- c. Image digitizer and storage
- c. Mechanism for tagging images with ancillary information
- d. Feature extractor
- e. Processor for characterizing the features
- f. Processor for creating a montage
- g. Display
- h. Mechanism for positioning the item within the camera field of view

1 d. display the similar pairs of images to a ballistics examiner who reviews the display and rules that
2 the unknown ballistic item is a match to an item in the database if the similar pair(s) of images are
3 sufficiently alike.

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5 6. Method of Claim 5. In which step f is performed automatically by further image processing

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7 7. Method of Claims 5 or 6 including also the step:

8 e. compare the weapon-specific and incident-specific tagging information of the similar image pairs

9 a. Display the similarities and dissimilarities in the tagging information along with the images for
10 further consideration by a ballistics examiner who reviews the display and rules that the
11 unknown ballistic item is a match to an item in the database if the tagging information as well as
12 the similar pair(s) of images are sufficiently alike.

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14 8. Method of Claim 7 in which step i. is performed automatically by further image processing.

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16 9. Method for identification of a ballistic item including the steps:

17 a. characterize the unknown ballistic item by producing a tagged extracted feature sequence

18 b. compare the extracted feature sequence with those contained in a database

19 c. determine those sequences in which one or more extracted features are similar to the unknown
20 extracted feature sequence

21 d. display the similar pairs of extracted features to a ballistics examiner who reviews the display
22 and rules that the unknown ballistic item is a match to an item in the database if the similar pair(s) of
23 extracted features are sufficiently alike.

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25 10. Method of Claim 9. In which step d is performed automatically by further image processing

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27 11. Method of Claims 9 or 10 including also the steps:

28 e. compare the weapon-specific and incident-specific tagging information of the similar extracted
29 feature pairs

- 1 20. The apparatus of claim 19 including also the elements:
 - 2 i. device for heating the ballistic item
 - 3 j. device for measuring the temperature of the ballistic device
 - 4 k. device for applying optical filters before the camera lens
 - 5 l. mechanism for tagging the resulting images with temperature and filter data
- 6
- 7 21. Apparatus for identifying a ballistic item including the elements of 20 plus:
 - 8 m. Database of characterized ballistic items
 - 9 n. Database matching engine
 - 10 o. Output or display mechanism
- 11
- 12 22. Method for identifying a ballistic item including the steps
 - 13 a. for each montaged image in the unknown item database and the known item database produce
 - 14 a relative location map as follows:
 - 15 b. compute the centroid location for each feature, including all striations, gouges, breech face
 - 16 marks, and firing pin indents, where each striation is considered a separate feature.
 - 17 c. Compute the distances between each pair of centroids
 - 18 d. Tag the distances with the type of feature represented at each end
 - 19 e. Match the list of tagged distances with corresponding lists for the known item database.
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- 21 23. Method for separating manufacturers marks from weapons marks in ballistic images, including the
- 22 steps:
 - 23 a. heating the ballistic item to temperature which enhances the manufacturers marks
 - 24 b. producing an infrared image of the ballistic item
 - 25 c. producing a template of the areas containing the enhanced manufacturers marks
 - 26 d. extracting the template areas to form an image containing the manufacturers marks
 - 27 e. the remaining image containng no manufacturers marks but containing weapons marks which did
 - 28 not overlay manufacturers marks.
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- 1 24. Method for estimating the volume of grooves, indentations and striations in ballistic items including the
- 2 steps:
- 3 a. heat the ballistic item to an elevated temperature
- 4 b. measure the mean temperature of the item using the radiometric infrared camera
- 5 c. capture a sequence of images as the item cools
- 6 d. capture for each image the mean temperature using the radiometric camera
- 7 e. estimate the volume of each depressed feature by determining its heat loss rate relative to the
- 8 mean temperature of the item, considering also the materials composition of the item.

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